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Polarization Dependent α-Factor in InGaAs/InGaAsP MQW Material

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Introduction: Multiple Quantum Well (MQW) structures are of high interest for many types of optical devices because of the improved performance. Material parameters such as the linewidth enhancement factor (α-factor) [1] and the related differential gain (dg/dN) and differential refractive index (dn/dN) are essential in the design of lasers and optical amplifiers, because they govern important properties as linewidth, frequency response and resonance frequency. So far, most of the characterization has been carried out for the TE-polarization, but the polarization dependence of these parameters is important to the optimization of the MQW structures.
Here we present measurements of the polarization dependence of dn/dN, dg/dN and the α-factor in a MQW amplifier. Theoretical results are also presented and reasonable agreement with measured data is obtained.

Measurements: The experiments are performed on a four-well MQW DC-PBH [2] amplifier with gain peak wavelengths of 1532 and 1500 nm for the TE- and TM-polarization, respectively. The *InGaAs* well layers and the *InGaAsP* barrier layers are 80 and 130 Å thick, respectively, as shown in the band diagram in Fig. 1. The guide layers are each 1000 Å thick and of the same composition as the barriers. The active stripe is $2.0\mu m$ wide and $800\mu m$ long. The facets are AR-coated giving residual reflectivities of approximately 10^{-3}.
Measurements of dn/dN, dg/dN and the α - factor are performed with a dynamic selfheterodyne method [3],[4], and the calculations are performed using a detailed model [5]. The TE-and TM-polarizations are considered at the respective gain peaks.

Discussion: Fig. 2 shows measured and calculated dn/dN vs. injection current for the two polarizations. At low injection currents dn/dN is significantly smaller for the TM-polarization, which can be explained as follows: Free carriers normally contribute to dn/dN, because of collision and relaxation processes (free carrier plasma effect). However, in a quantum well the carriers are not free to move in the direction perpendicular to the well, and therefore will not contribute to dn/dN for TM-polarized light. For high injection currents, the difference in dn/dN between the two polarizations becomes negligible. This is not in accordance with the theoretical predicted difference, which is mainly due to the plasma effect, and nearly independent of the injection level (carrier density). However, carrier overflow [4],[6] is not included in the calculations. This could explain our experimental data, since carriers leaking into the barrier states will contribute to the plasma effect even for the TM-polarization, thus reducing the dn/dN difference at higher injection currents. Figure 3 shows the measured and calculated values for dg/dN vs. the injection current for the TE- and TM-polarizations. The measured dg/dN is smaller for the TM-polarization at low injection, but are identical for the two polarizations at high injection levels. Contrary to this, the theoretical results show higher values of dg/dN for the TM polarization. The theoretical predictions are considerably larger than the measured values. A better agreement might be achieved by including carrier overflow in the model. This would tend to saturate the predicted gain at high injection currents, since the carriers in the barrier states do not contribute to the gain. The measured and theoretically predicted results for the α-factor vs. injection current are shown in Fig. 4. It is worth noting, that in spite of the smaller measured values of dg/dN at low injection for the TM-polarization there is no difference in the α-factors due to the absence of the plasma effect for the TM polarization. Fig. 5 shows the measured α-factor vs. single pass gain for the two polarizations. As the α-factor for a given gain is larger for the TM-polarization an improvement of the linewidth for a MQW laser oscillating in TM-mode is not immediately expected. However, the application of tensile strained layer MQW, which increases the TM gain above the TE gain, might change this, since the plasma effect would still be absent for the TM-polarization. Low α-factors in tensile strained MQW material has in fact been reported in in [8].

Conclusion: The polarization dependence of the α-factor has been investigated for unstrained MQW material. Experimentally the α-factor has been found to be smaller for TE compared to TM-polarization at a given gain. However, it has been pointed out that the contribution from the free carrier plasma effect to the refractive index is negligible for TM-polarized light at low injection levels. This leads to a significant reduction in dn/dN compared to the TE-polarization and is important in relation to strained MQW lasers. These can be made to oscillate in the TM-mode with potential reduction of the α-factor.

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References

[1] C. Henry: J. Quantum Electronics Feb. 1982, pp. 259-264.

[2] H. Asano et al: In proc. of OFC'91, paper WG1.

[3] N. Storkfelt et al.: Photon. Technol. Lett., July 1991, pp. 632-634.

[4] M. Yamaguchi et al.: In proc. of ECOC'91, paper TuA3-2.

[5] K.S.Jepsen et al., accepted for publ. in Photon. Technol. Lett., June 1992.

[6] W.F.Sharfin et al.: In proc. of ECOC'91, paper TuA4-4.

[7] J.Lee et al.: J. Quantum Electronics, March 1992, pp. 624-634.

[8] P.Thijs et al.: J. Quantum Electronics, June 1991, pp. 1426-1439.

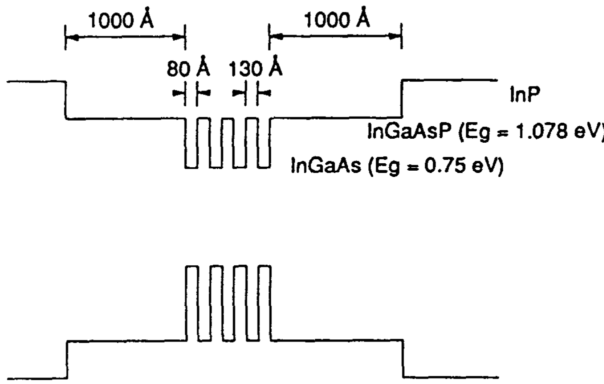

Figure 1: Energy band diagram of the MQW amplifier.

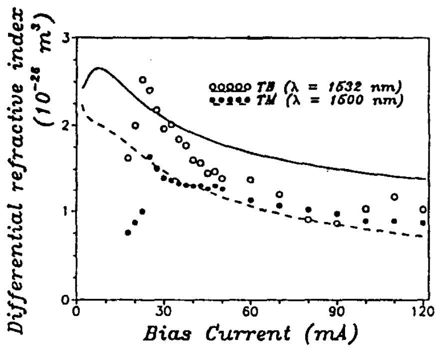

Figure 2: Differential refractive index dn/dN vs. injection current. The lines are calculated.

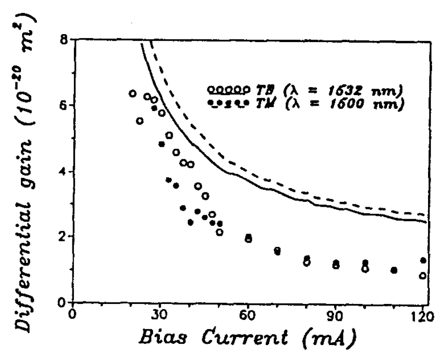

Figure 3: Differential gain dg/dN vs. injection current. The lines are calculated.

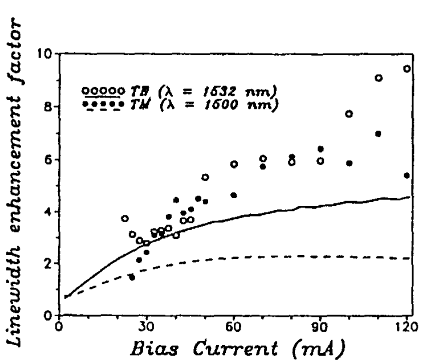

Figure 4: α-factor vs. injection current. The lines are calculated.

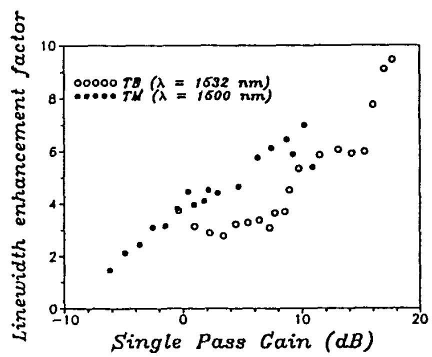

Figure 5: α-factor vs. single-pass gain.